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(71) Applicant
Citizen Watch Co Ltd (Japan),
2-1-1 Nishishinjuku, Shinjuku-ku, Tokyo, Japan

(72) Inventors
Hirohiko Yoshida
Minoru Natori

(74) Agent and/or Address for Service
D Young & Co,
10 Staple Inn, London WC1V 7RD

(54) Multicolor picture display device

(57) A multicolor picture display device particularly for use in a portable color television is disclosed. The display device comprises a spectrocscopic unit 12-15 for making a spectral diffraction of light wavelengths and an image display unit (16) including a light valve which has a plurality of picture-forming elements and which serves to receive light from the spectroscopic unit and control the quantity of outgoing light of the three primary colors. The spectroscopic unit comprises a first lens system 12 and a second lens system 13 which converts a wide collimated light to a narrow collimated light. This is applied to a prism 14. The refracted light components are applied via a lens system 15 to a display panel which may be liquid crystal or electrochromic. A scattering plate may be used instead of the light source 11. A mirror may be interposed between the panel and the eye. Alternatively, the panel itself is inclined and includes a reflective coating.

Fig. 3

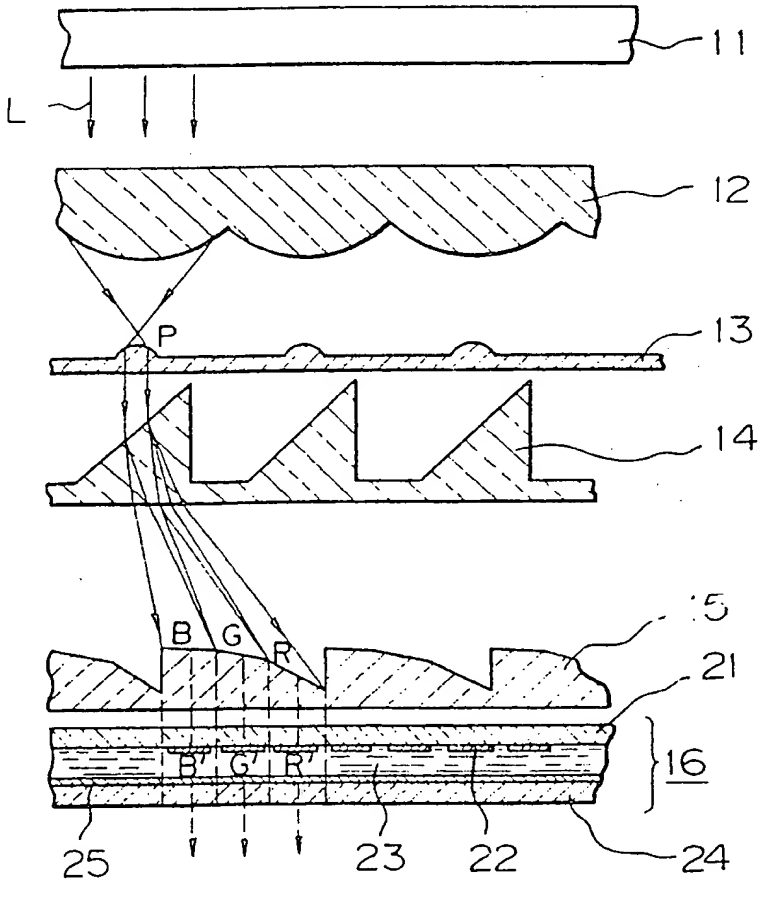

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Fig. 1

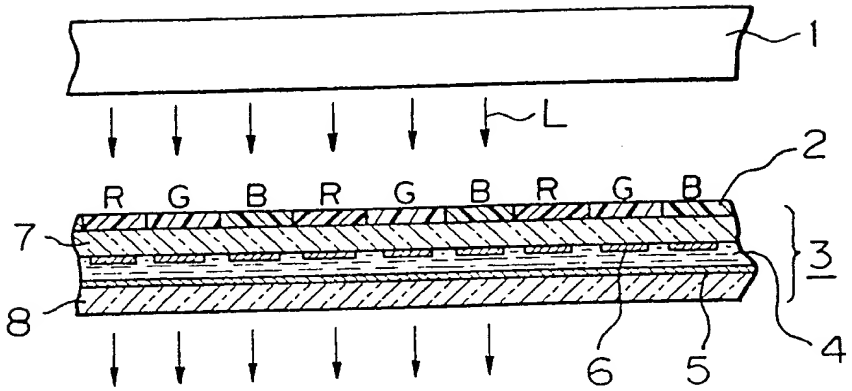


Fig. 2

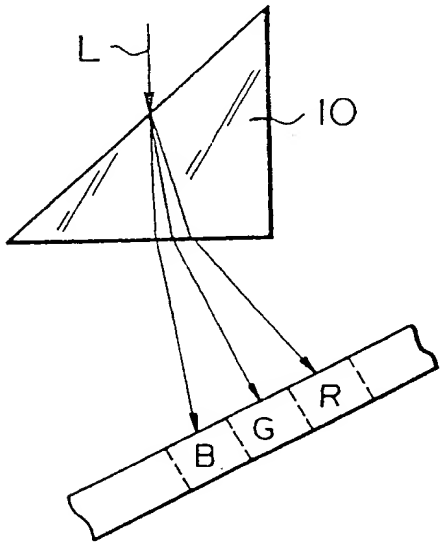


Fig. 3

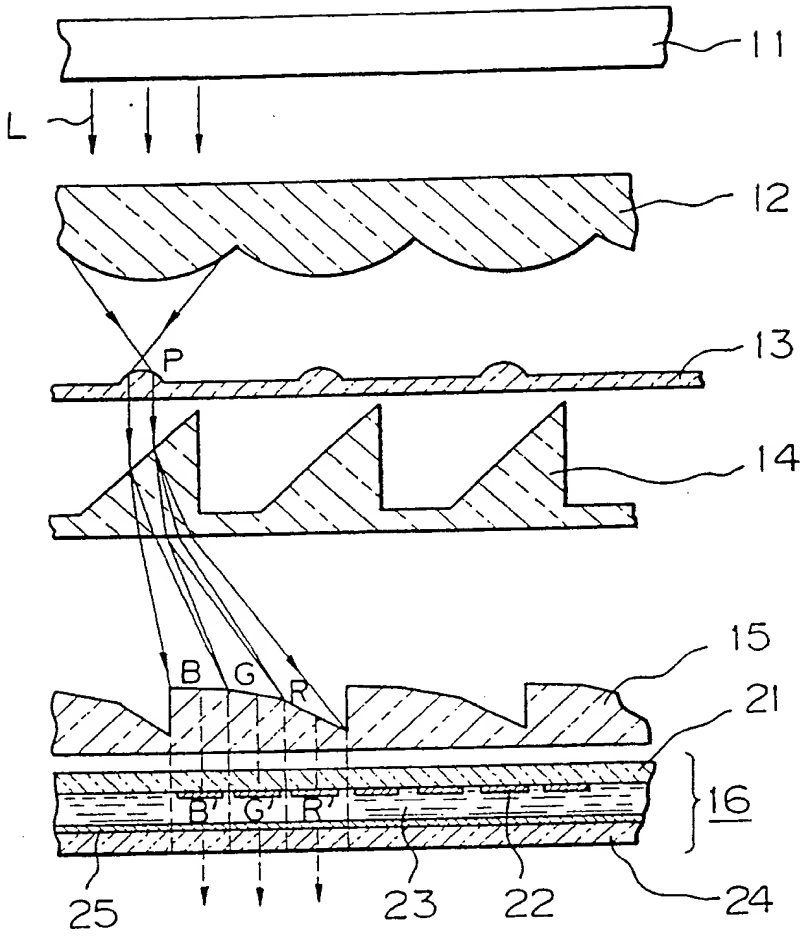


Fig. 4

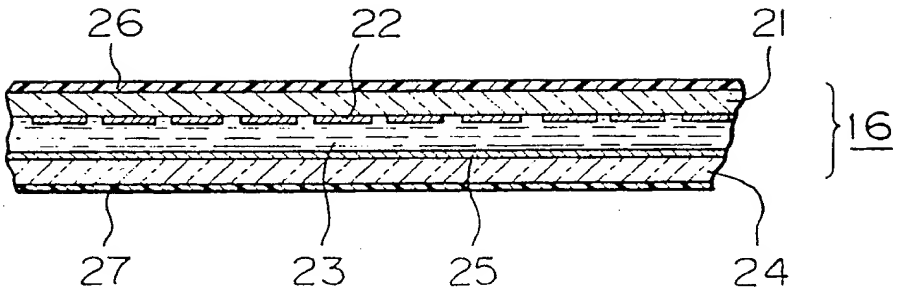


Fig. 5

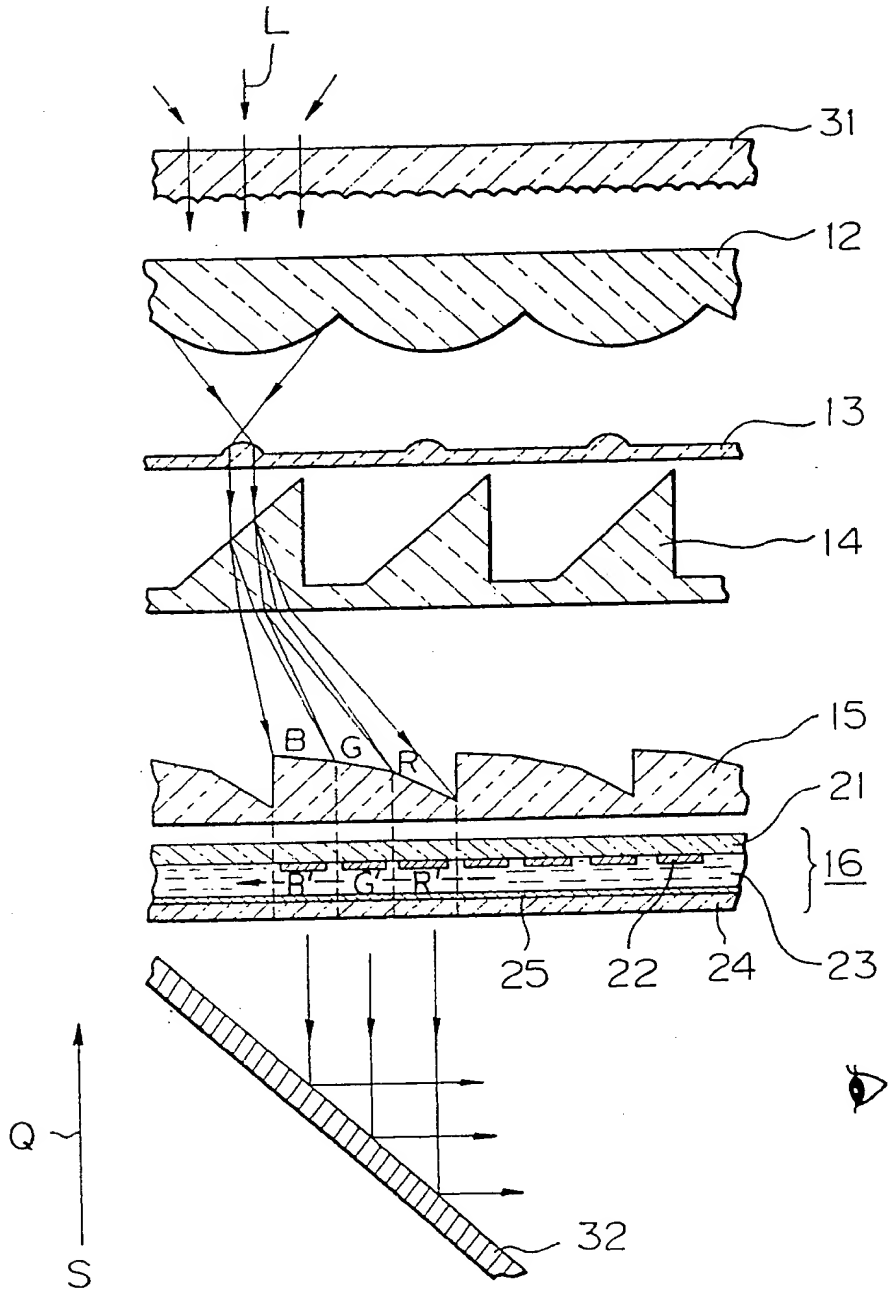
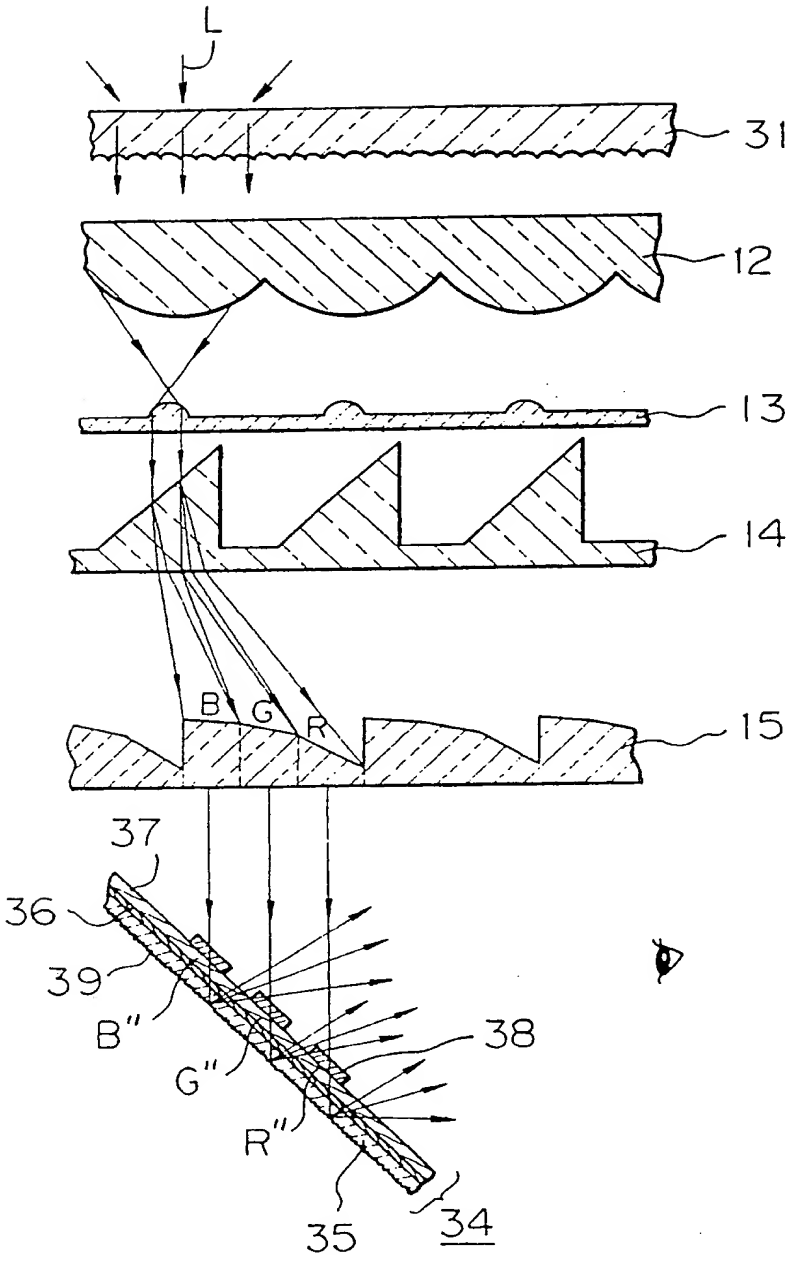


Fig. 6



SPECIFICATION

Multicolor pictur display device

The present invention relates to a multicolor picture display device of a passive type such as a display panel of, for example, a color liquid crystal television receiver.

There has recently been developed a display panel employing a passive display element such as a liquid crystal element which may be utilized in a number of applications. One of these applications is a technique for determining the color of respective picture-forming elements arranged in a matrix by a multicolor filter arranged in a stripe or mosaic pattern, and controlling the brightness of the picture-forming elements separately, thereby generating a multicolor video image or picture.

Fig. 1 of the accompanying drawings schematically shows a conventional multicolor video liquid crystal display device. Substantially white light is incident on a color filter 2 from a light source 1. The color filter 2 comprises respective color regions of the three primaries red (R), green (G) and blue (B) corresponding to a number of electrodes 6 of a liquid crystal light valve 3. The term "light valve" is used herein to mean a device for controlling outgoing light quantity from incident light quantity so that the outgoing light quantity may be decreased to zero. The light valve 3 comprises signal electrodes 6, a plurality of scanning electrodes 5, liquid crystal material 4 sandwiched by these electrodes 6 and 5, and upper and lower glass plates 7 and 8 for sandwiching these electrodes 6 and 5 therebetween, thereby forming a number of picture-forming elements arranged in a matrix. After light L passes through the color filter 2 respective picture-forming elements of the light valve 3 pass the light having any one of the three primaries R, G and B. In this case the amount of transmitted light is controlled by a voltage applied between the signal electrodes 6 and the scanning electrodes 5. When using the liquid crystal in a mode utilizing polarization, such as a TN (twisted nematic) mode, the upper and lower glass plates 7 and 8 are provided with polarizing plates (not shown). In this way a video image or picture of natural color may be displayed. In a conventional passive multicolor display device, however, the effective quantity of transmitted light is decreased to about 1/3 of the incident light quantity since the color filter is utilized to obtain color light from a white light source. In order to display an image with a natural color the decrease of light quantity in the light valve must further be taken into account. Conventional display devices, therefore, have a very low display brightness. For example, it is not usually possible to recognize an image or picture under usual room brightness, so that it is necessary to utilize a special light source for illumination. Thus, the light source must have a substantially large brightness with the result that the power-consumed for illumination is very large. For small and portable display devices, such as a pocketable television, therefore, the lifetime of a battery cell would be very short or the display would be very dark.

We have now found it possible to overcome the above described disadvantages of conventional display devices. Thus, we provide a multicolor picture display device having a high brightness without decreasing the effective light quantity.

According to the present invention there is provided a multicolor picture display device comprising means for making a spectral diffraction of light wavelengths and an image display unit including a light valve which has a plurality of picture-forming elements and which serves to receive light from the spectroscopic means and control the quantity of outgoing light of the three primary colors.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings wherein like reference numerals designate like or functionally equivalent parts throughout, and wherein;

Figure 1 is a sectional view schematically showing a conventional multicolor video liquid crystal display device (as described above);

Figure 2 is an explanatory view showing the principle of a multicolor picture display device according to the present invention;

Figure 3 is a sectional view showing one embodiment of a multicolor picture display device according to the present invention;

Figure 4 is an enlarged sectional view illustrating a modification of the liquid crystal light valve shown in Fig. 3;

Figure 5 is a sectional view showing another embodiment of a multicolor picture display device according to the present invention; and

Figure 6 is a sectional view showing a still further embodiment of a multicolor picture display device according to the present invention.

Referring to the drawings, there is shown embodiments of a multicolor picture display device according to the present invention.

Fig. 2 schematically shows a multicolor picture display device. According to the present invention use is made of means for making a spectral diffraction of light wavelengths preferably with the conversion of a wide collimated light beam into a narrow collimated light beam, since if the wide collimated light beam is directly incident to the spectroscopic means the width of the outgoing light beam becomes large. In this case the width of color regions R, G, B is large so that the wavelength component of for example R is also incident on a plurality of adjacent picture-forming element regions. In order to

avoid this defect the brightness may be sacrificed so that on color wavelength component is incident on one picture-forming element region.

If a wide collimated light beam is incident on the spectroscopic means the outgoing light is divided into three color components R, G and B at a distance from the spectroscopic means so that the device becomes large.

According to an embodiment of the spectroscopic means shown in Fig. 2 a narrow collimated light beam is incident on the spectroscopic means so that the outgoing light is divided into three components R, G and B near the spectroscopic means, and thus the display device can be made small.

Fig. 3 shows one embodiment of a multicolor picture display device according to the present invention. The display device comprises a light source 11, a first lens system 12, a second lens system 13, a prism system 14 to serve as the spectroscopic means, a third lens system 15 (not having a spectroscopic function), and a liquid crystal light valve 16. Substantially white collimated light obtained from the light source 11 is incident on the first lens system 12. This incident light is condensed at a point P which is a focus of the first lens system 12 and a focus of the second lens system 13 having a shorter focal length than that of the first lens system, and near thereof and then passed through the second lens system 13 to give a parallel or substantially parallel light beam narrower than that incident on the first lens system. This narrow and parallel light beam or flux is incident on the refracted by the first prism system 14. Since in the prism system 14 the refractive index increases as the wavelength of the light decreases in the order R, G and B, the bending angle of the light beam becomes large due to refraction and the light beam widens as a whole with a continuous variation in wavelength. Thus, the beam generally divides into three color regions in order of the three primary components B, G and R, as shown from left to right in Fig. 3, and is thereafter incident as different light beams on the surface B, G and R of the third lens sytem 15 which have different inclined angles respectively.

These light beams or fluxes are refracted with different angles, respectively, and then incident on respective picture-forming elements B′, G′ and R′ of the liquid crystal light valve 16 as a parallel light beam or flux with different colors. The liquid crystal light valve 16 comprises an upper transparent base plate 21, a number of transparent signal electrodes 22 provided on the plate 21, a liquid crystal material 23, a lower transparent base plate 24, and a number of transparent scanning electrodes 25 provided on the lower plate 24 to give picture forming elements in the form of a matrix by sandwiching the liquid crystal material 23 between electrodes 22 and 25. Respective picture-forming elements of the light valve 16 pass the light of any one of the three primaries R, G and B and control the amount of light transmitted according to the voltage applied between the signal electrodes 22 and the scanning electrodes 25 to give a display of a video image or picture with a natural color.

Fig. 4 shows a modification of the display device shown in Fig. 3. In this modification the upper and the lower base plates 21 and 24 and provided with polarizing plates 26 and 27, respectively. This arrangement is adopted when the liquid crystal is used with polarization, for example, such as in the TN mode.

Fig. 5 shows another embodiment of a multicolor picture display device according to the present invention. In this embodiment a scattering plate 31 is provided instead of the light source 11 so as to receive external light from various angles and to form substantially collimated light rays incident on the first lens system 12. Reference numeral 32 is a reflecting mirror to produce a mirror image Q of natural color by reflecting the light passed through the light valve 16 so that the image can be viewed from the right hand side. The construction and advantageous effect of the other parts of the device are the same as those of Fig. 3.

Fig. 6 shows a further embodiment of a multicolor picture display device according to the present invention. In this embodiment an electrochromic light valve 34 is provided instead of the liquid crystal light valve 16 shown in Figs. 3 and 5. The light valve 34 comprises a lower transparent base plate 35, a plurality of transparent scanning electrodes 36, an electrochromic (EC) material 37 stacked or laminated thereon, a plurality of transparent signal electrodes 38 laminated thereon and a reflection coating 39 provided on the undersurface of the lower base plate 35. The EC material 37 is sandwiched between the signal electrodes 38 and the scanning electrodes 36 thereby forming a matrix of shaped picture forming elements. The light beam or flux transmitted through the prism system 14 and collimated by the third lens system 15 is divided into color regions in order of the three primary components B, G and R from the left hand side of the drawing and incident on respective picture forming elements B″, G″ and R″ of the electrochromic light valve 34. Respective picture-forming elements control the strength of incident light on the reflection coating causing irregular reflection. The strength of the reflection light from the reflection coating passed through the EC material 37 is also controlled by the regulation of the voltage applied between the signal electrodes and the scanning electrodes so that the strength of the outgoing light may be finally controlled for every pic-

ture-forming element. This embodiment enables the video image with a natural color to be viewed from the right hand side.

In an alternative of the embodiment shown in Fig. 6, a liquid crystal display element of reflection type may be utilized instead of the electrochromic display element of reflection type as a light valve. Though first, second and third lens systems are utilized in the embodiments shown in Figs. 3, 5 and 6, these lens systems may be omitted so that only the prism system provides the above described advantageous effects. In this case the brightness obtained by the display device according to the present invention is reduced.

As described above, respective picture-forming elements according to the invention are colored with spectroscopic means without using a color filter which absorbs light as in the prior art. An image is thereby obtained having a brightness which is about three times greater than that obtained with prior art devices, and thus a video image with a natural color may easily be seen in a room of usual brightness. A portable color display device such as a portable color television of pocketable size may therefore be obtained having sufficient brightness and battery lifetime.

CLAIMS

1. A multicolor picture display device comprising means for making a spectral diffraction of light wavelengths and an image display unit including a light valve which has a plurality of picture-forming elements and which serves to receive light from the spectroscopic means and control the quantity of outgoing light of the three primary colors.

2. A multicolor picture display device as claimed in claim 1 wherein the spectroscopic means comprises a prism array.

3. A multicolor picture display device as claimed in either of claims 1 and 2 wherein the light valve comprises a liquid crystal device.

4. A multicolor picture display device as claimed in either of claims 1 and 2 wherein the light valve comprises an electrochromic device.

5. A multicolor picture display device as claimed in claim 3 wherein the liquid crystal device comprises a twisted nematic liquid crystal device having polarizing means.

6. A multicolor picture display device as claimed in any one of the preceding claims having an optical system including a first lens system and a second lens system.

7. A multicolor picture display device as claimed in claim 6 wherein the first lens system comprises at least one condenser lens and the second lens system comprises at least one collimating lens.

8. A multicolor picture display device substantially as herein described with reference to Figs. 2 to 6 of the accompanying drawings.

9. A television incorporating a device as claimed in any one of the preceding claims.

10. Each and every novel process, method, product and apparatus substantially as herein described.

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